CoorsTek Sintered SiC for Space Based Telescopes
Mirror Technology Days 2004

Overview of EADS Astrium NIRSpec Development Program

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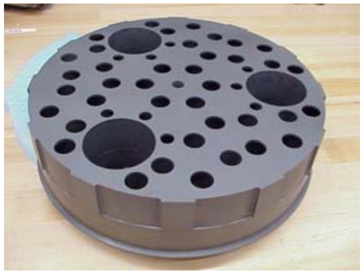
Global Sintered SiC Technology Alliance

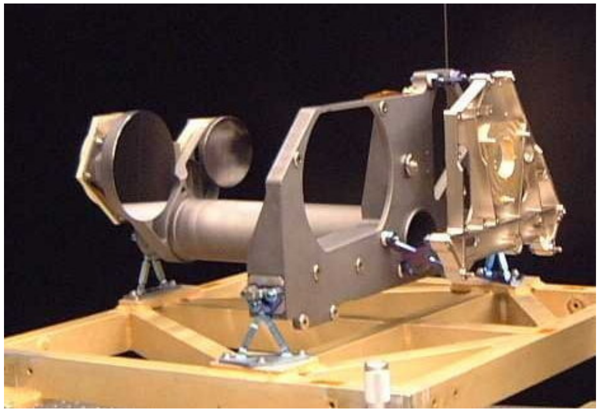
COORSTEK Amazing Solutions.

- US Largest Technical Ceramics Manufacturer
- 90 Year history
- Specialized in micron-level precision structures multi-meter class structures for industry
- High volume precision component supplier, >500 per month
- 180 tons of sintered SiC powder processed per year



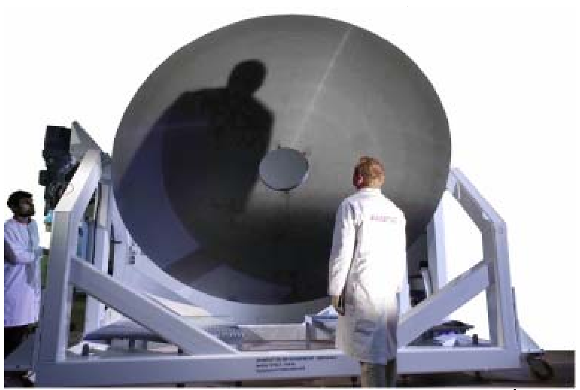
BOOSTEC INDUSTRIES

- 10 years of R&D for sintered SiC for optical applications
- Proven/space qualified SiC manufacturing technology
- 2 all-SiC space telescopes currently in operation
- Sintered SiC technology similar to CoorsTek's



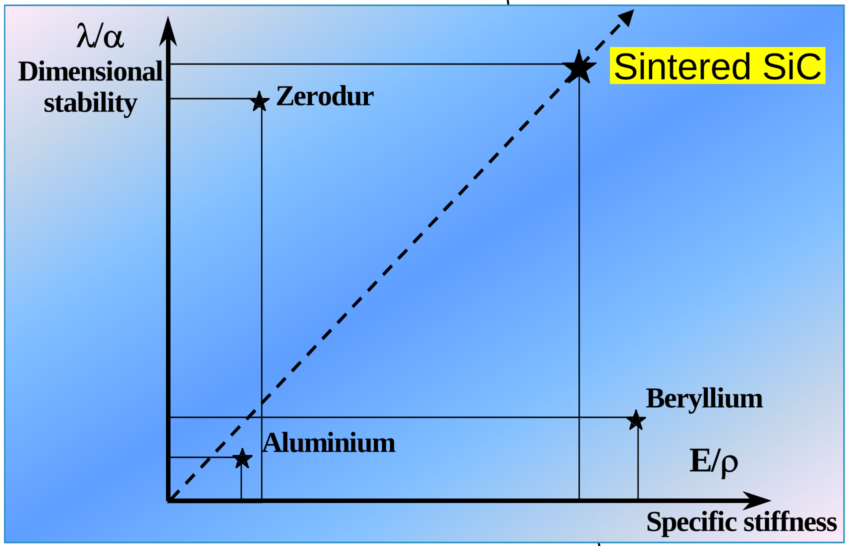
EADS ASTRIUM

- 10 years of design and testing sintered SiC for space based optical applications
- Europe's largest satellite integrator
- Contracts design for next generation space telescopes Herschel, SPICA, GAIA, NIRSpec (JWST)



Sintered silicon carbide is the best material for space optical assemblies

- Sintered SiC is an homogeneous material, with an isotropic microstructure.
- The material shows a very high specific stiffness and a very high stability (low sensitivity to thermal gradients).
- It allows to obtain very stiff , lightweight and stable structural parts and reflectors.
- It can be polished with the standard glass polishing techniques.
- The industrial process used by Boostec and CoorsTek has 20 years of mass production experience (automotive, chemical engineering, …).
- Its physical properties are furthermore reproducible in time, from batch to batch.



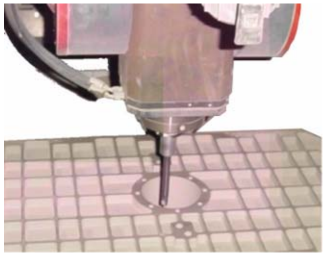
λ : 180 W.m^{-1}.K^{-1}
α : 2 ppm.K^{-1}
E : 420 GPa
ρ : 3150 kg.m^{-3}

Manufacturing process : From powder to part

1 2 3 4 5

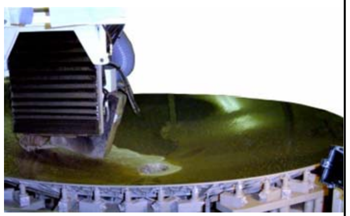
Powder

Isostatic pressing



Green machining

Sintering



Grinding

NIR-SPEC(Near-Infrared Multi-Object Spectrograph) Instrument Overview

E. SEIN

EASDS-ASTRIUM

Mission and Main design Drivers

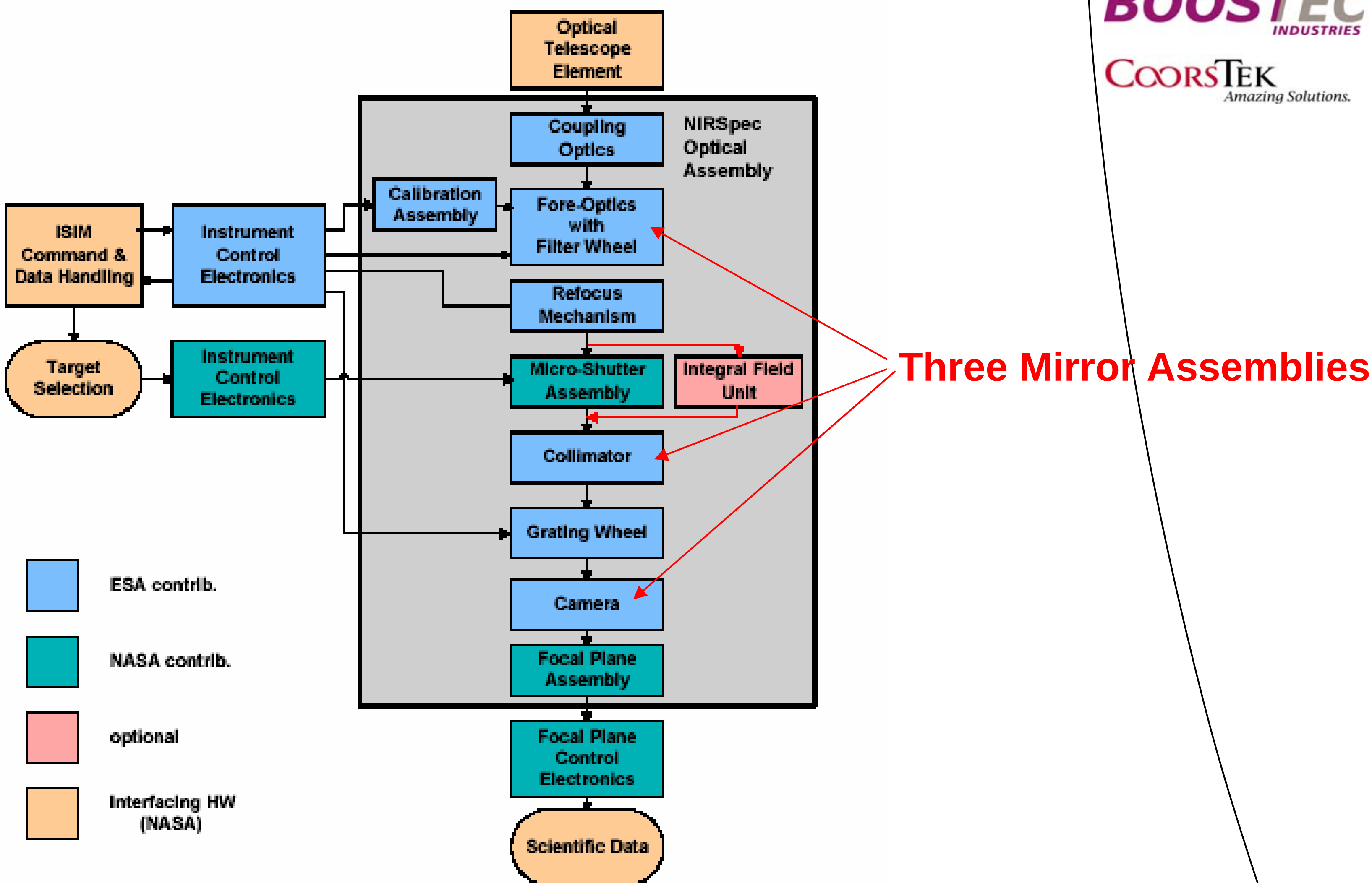
- The main mission objective for NIRSpec :
  - is to measure the formation and evolution of galaxies,
  - the star formation rate and
  - chemical abundances of young galaxies.

- The core task for NIRSpec is to observe more than 100 objects simultaneously in the near infrared region (1-5 µm) with a high spectral resolution (R ~ 1000) and highest possible sensitivity

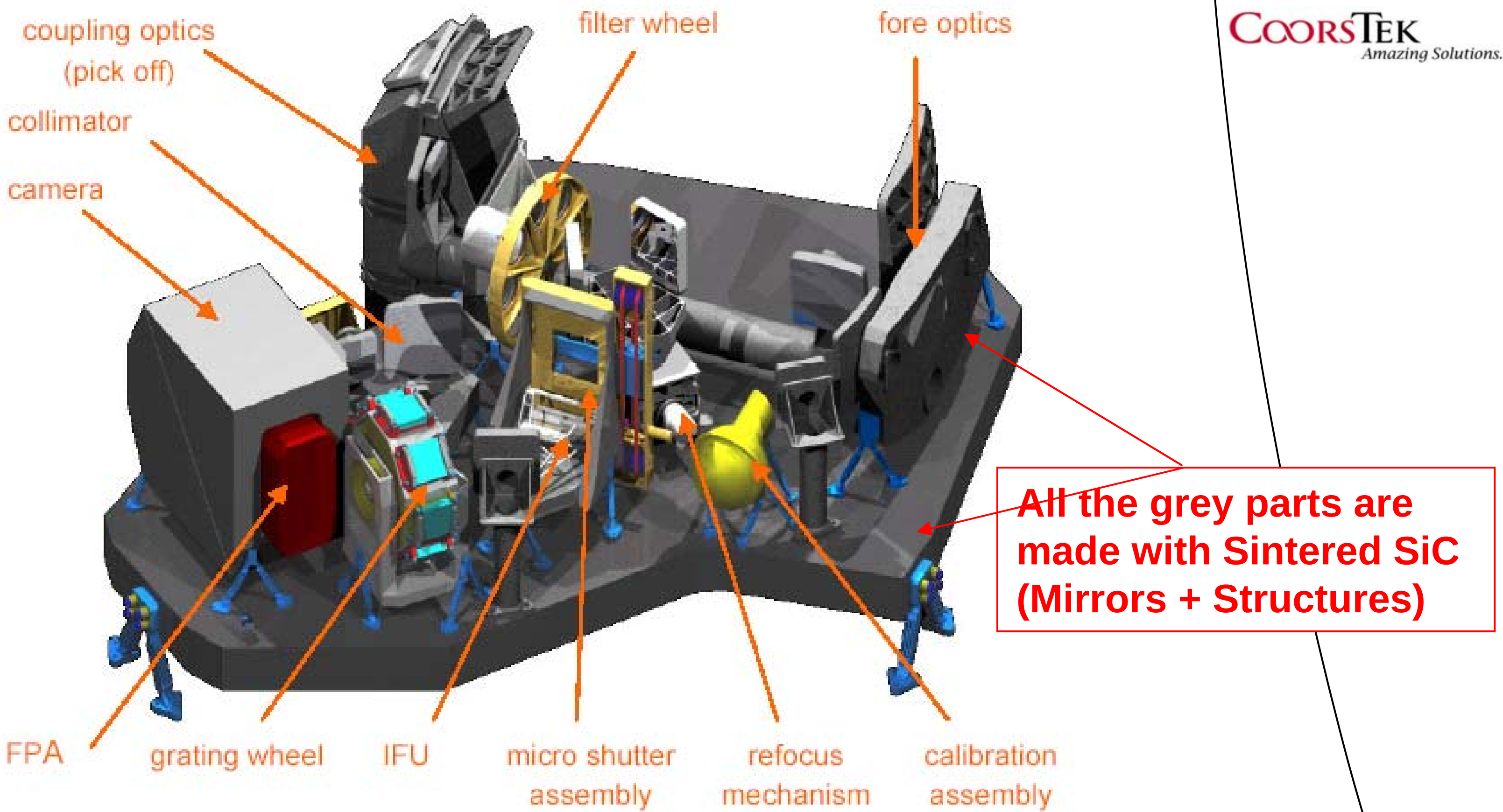
- After launch and commissioning of NIRSpec in 2011 and 2012 respectively, the instrument must operate for a nominal mission duration of 5 years until 2017.

- The main Instrument design drivers are:
  - the instruments of JWST require cryogenic temperatures **(37 K)** in order to achieve the infrared Spectral Band
  - a high instrument reliability using robust and mature technologies
  - **an athermal opto-mechanical design using a suitable homogeneous material to cope with the low operational temperature**
  - an optics concept with nine aspherical surfaces separated into assemblies with uncritical relative alignment tolerances.

NIRSpec functional Breakdown



NIRspec Preliminary Design



Total Mass: 185 kg
Length/width/Height/: 1800/1400/1000 mm

Key Features of the Technical solution

❑ Key features of the Opto-Mechanical Design

The configuration, design and material selection is driven by the objective to ensure lowest distortion under thermal load and gravity release and to acheive a lightweightand robust structure

- **all SiC design for structures and mirrors**
- **kinematic mounting of all assemblies onto the Optical Bench**

❑ Key features of the Mechanisms

The NIRSpec-optical bench is equipped with three mechanisms

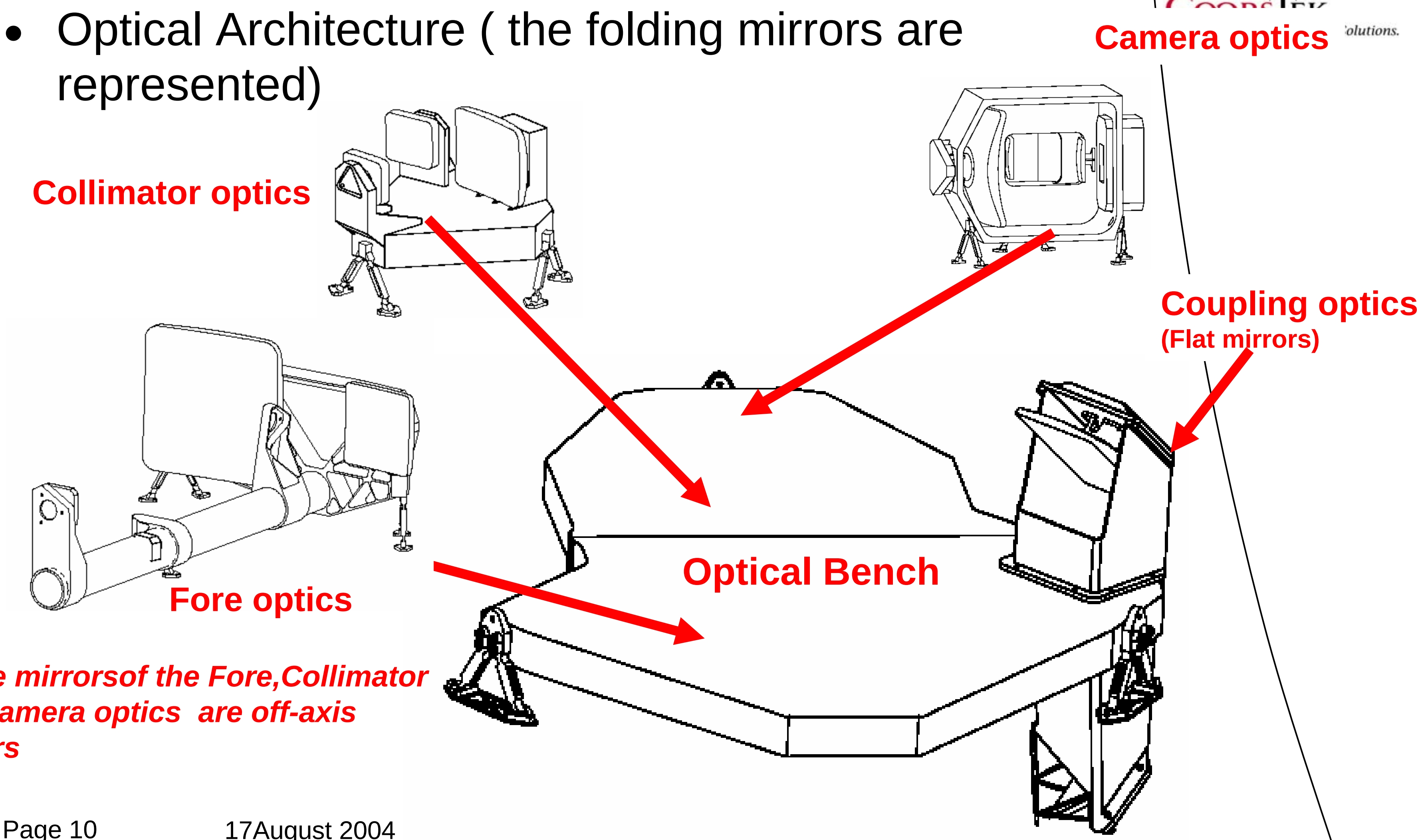
- A grating wheel to select one out of eight positions equipped with six gratings, one prism and one mirror.
- A filter wheel to select one out of eight positions equipped with order sorting and bandpass filters and one open and one calibration position.
- A refocusing mechanism providing a refocusing capability of 14.8 mm total stroke at the OTE I/F compared to the required 6.2 mm.

The design Drivers fao all meachanisms are:

- The stringent position accuracy ,stability and repeatability at 37 K
- Very low dissipation

Key Features of the Opto-mechanical Design (1)

- Optical Architecture (the folding mirrors are represented)



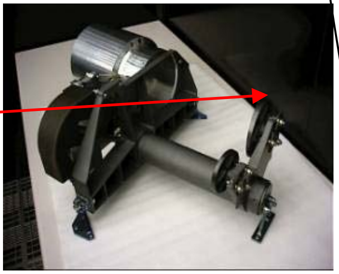
All the mirrorsof the Fore,Collimator and Camera optics are off-axis mirrors

Key Features of the Opto-mechanical Design (2)

The optomechanical design of NIRSpec is based on the sound experience of ASTRIUM in development space optics in Silicon Carbide

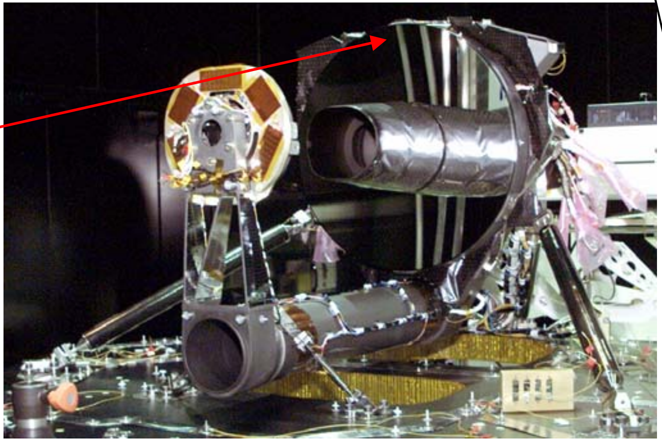
- **HERSCHEL** and **GAIA** programs currently in development
- **OSIRIS Camera** (Space qualified and Launch in March 2004)

Φ 130 mm



- **ROCSAT Camera** (Space Qualified Launched in May 2004)

Φ 600 mm



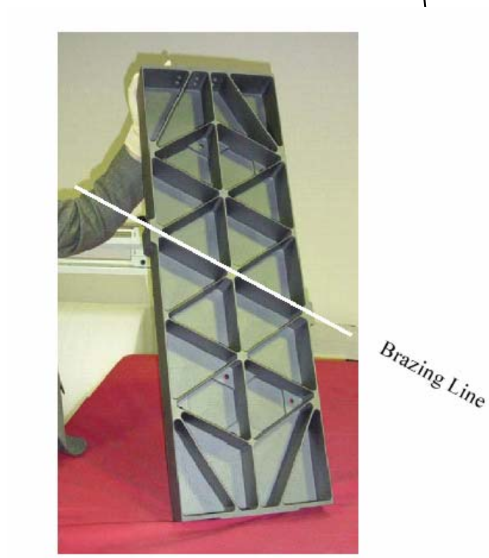
Key Features of the Opto-mechanical Design (3)

- The primary goal of the structural design must minimise the degradation of the optical performance du to
  - gravity release
  - cool down from ambient temperature to 37 K (no cryofiguring are foreseen for optical elements)
- The opto mechanical performances for the Off Axis mirrors

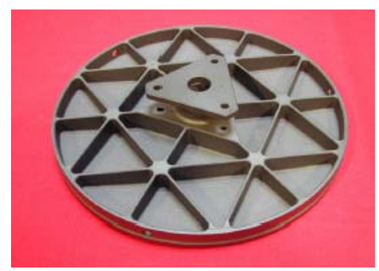
Mirror	Expected WFE RMS	Required Mechanical Stability Under environmental conditions
Fore Optics M1	20 nm	80 µm
Fore Optics M2	20 nm	80 µm
Fore Optics M3	20 nm	80 µm
Collimator M1	50 nm	15 µm
Collimator M2	50nm	15 µM
Collimator M3	30nm	80 µm
Camera M1	30nm	30 µm
Camera M2	30nm	30 µm
Camera M3	50 nm	30 µm

Key Features of the Opto-mechanical Design (4)

- During the preliminary phase an exhaustive characterization of materials were performed showing the very attractive performances of the sintered SiC in comparison a with other ceramic (CSIC) or more classical material (CFRP) convincing our customer (ESA) that sintered SiC it the most suitable material for large, stable and cryogenics optics
- During preliminary phase a large Breadboard of the brazed optical bench (length 1m) was developed and tested demonstrating that the this structure can carry more than two the design limit load
- Mirrors with CVD coating were succesfully tested under cryogenics conditions (20 K)
- These results were presented to NASA before SiC selection during preliminary definition phase



Optical Bench Breadboard



Φ 300 tested Mirror